Emission Reduction Opportunities for Non-CO_2 Gases in California

Presented by Anne Choate, ICF Consulting
September 14, 2005

Overview

- Study Parameters
- Model Parameters
- MACC Development
  - Baseline Emissions
  - MACC Inputs
  - Discounted Cash Flow Analysis
  - Data Sources
- Results
- Next Steps

Study Parameters

- Objective: evaluate the potential for reducing California GHG emissions through mitigation actions targeting non-CO_2 gases
- Scope: include only those actions to reduce non-CO_2 gases for which cost and emission reduction data was available in published literature
- California-specificity: modify emission reduction potentials and costs to reflect California-specific conditions where possible

Model Parameters

- Timeframe: 2000-2020
  - Reference Year: 2000 (relatively recent year with readily available data)
- "No Further Regulatory Action" Baseline
- Sources
  - Petroleum Systems, Natural Gas Systems, Landfills, Manure Management, Electric Power Systems, Semiconductor Manufacture, Refrigeration/Air- Conditioning
  - Omitted sources with minimal potential for GHG reductions and those addressed by other CEC projects
  - 59 mitigation options

Model Parameters (cont'd.)

- Greenhouse Gases
  - CH_4 and high-GWP gases (HFCs, PFCs, and SF_6)
  - Emissions expressed in metric tons of carbon dioxide equivalent (MTCO2 Eq.)
- Scenarios
  - Discount Rate: 4%; Tax Rate: 0% ~ societal costs
  - Discount Rate: 20%; Tax Rate: 40% ~ private costs

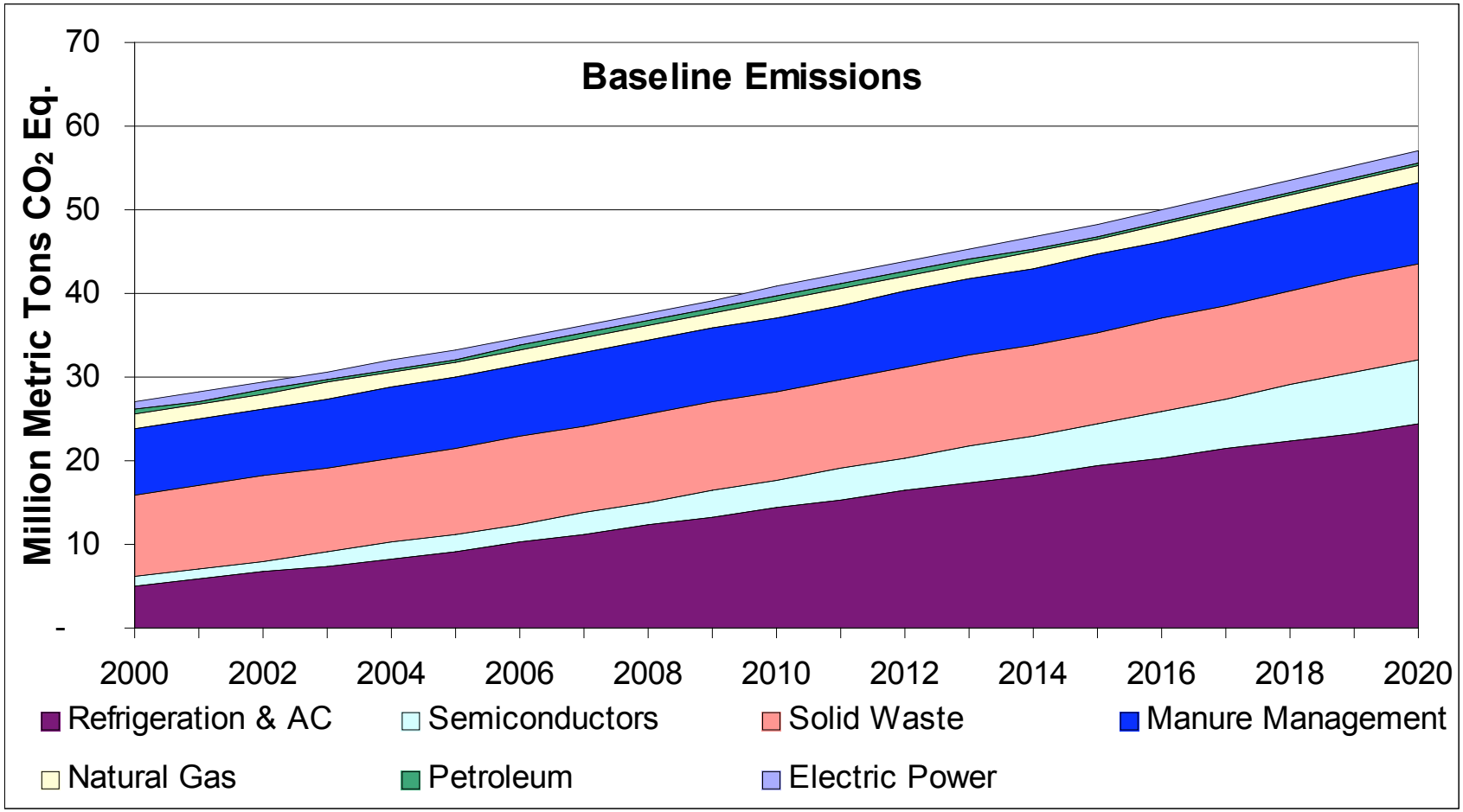
MACC Development

- Baseline Emissions
- MACC Inputs
- Discounted Cash Flow Analysis
- Data Sources

Baseline Emissions – Baseline Definition

- No Further Regulatory Actions Baseline
  - Reflects reductions from voluntary actions implemented prior to the end of 2000
  - Reflects reductions from regulatory actions implemented by the end of 2000
  - Does not reflect any further actions – voluntary or regulatory – that occur after the end of 2000

Baseline Emissions – Results



MACC Inputs – Cost Data

- Costs
  - Annual (O&M)
  - Capital (One-Time)
  - Chemical / Agent
- Savings
  - Energy Savings
  - Non-Energy Savings

Adjustments for California

- Relative Electricity Prices
- Relative Natural Gas Prices
- Chemical / Agent Costs
- Air Pollution Control Costs
- Growth Rates

Example:	**Improved HFC-134a in MVACs**
One-Time Cost ($2000/MTCO$_2$ Eq.)	$ 404.80
Annual Cost ($2000/MTCO$_2$ Eq.)	$ -
2010 Annual Benefit - Energy ($2000/MTCO$_2$ Eq.)	$ 167.40
2010 Annual Benefit - Non-Energy ($2000/MTCO$_2$ Eq.)	$ 0.90
2020 Annual Benefit - Energy ($2000/MTCO$_2$ Eq.)	$ 167.40
2020 Annual Benefit - Non-Energy ($2000/MTCO$_2$ Eq.)	$ 0.90

MACC Inputs – Emission Reductions

- Emission Reductions (ER) calculated based on:
  - Market Penetration (MP): *Market penetration* is the likelihood that an option will be adopted for a given source category
  - Technical Applicability (TA): The percentage of the baseline to which a mitigation option may be applied is called its *technical applicability*
    - E.g., in the refrigeration and air conditioning source category, some options that can reduce emissions from motor vehicle air conditioners cannot be applied to stationary air conditioning equipment
  - Reduction Efficiency (RE): *Reduction efficiency* addresses the portion of emissions that cannot be mitigated through application of a given mitigation option
    - E.g., landfill flares cannot eliminate all methane emissions, as some of that methane escapes from the collection systems

Discounted Cash Flow Analysis

$$\sum_{t=1}^{T}\left[\frac{(P\cdot ER_t)(1-TR)+R(1-TR)+TB)}{(1+DR)^t}\right]=CC_0+\sum_{t=1}^{T}\left[\frac{RC(1-TR)}{(1+DR)^t}\right]$$

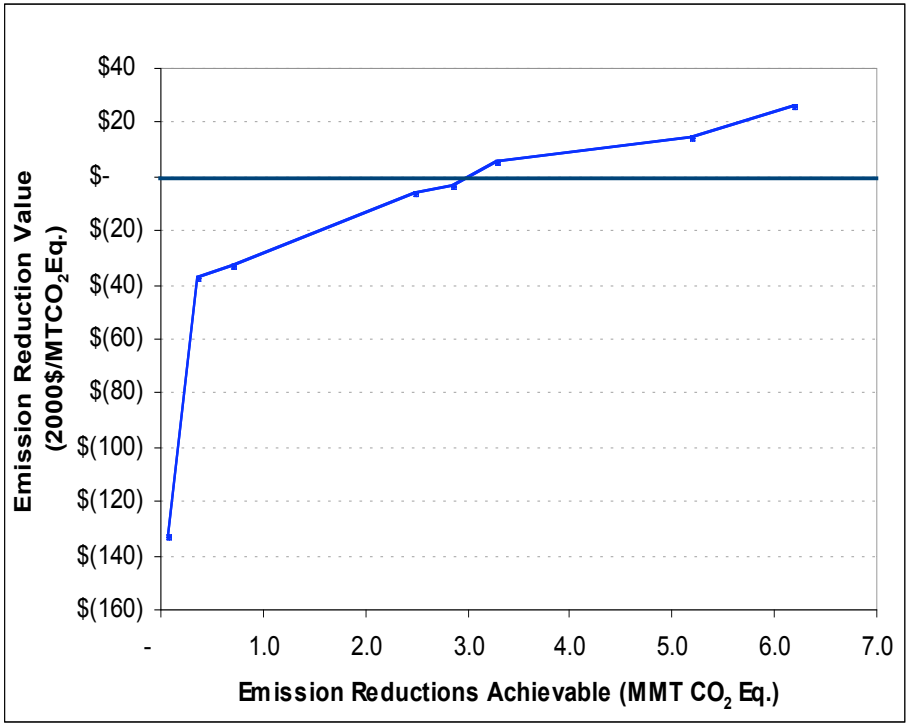
- *P* is the break even price of the option in $/TCO$_2$Eq.
- ER_t is the emissions reduction achieved by the technology in year *t*
- *R* revenue generated from energy production (scaled based on regional energy prices) or savings (e.g., from the use of less expensive ODS substitutes), in 2000 U.S. dollars
- *T* is the option lifetime
- *DR* is the selected discount rate
- CC_0 is the capital cost of the option
- *RC* is the annual cost of the option
- *TR* is the tax rate
- *TB* is the tax break ($CC_0/T * TR$)

Sample Output

Example of MACC – CA Refrigeration/AC, 2020 (4% DR; 0% TR)

Schedule of Mitigation Options for Refrigeration/AC in 2020			
Option	Break-Even Cost (2000$/MTCO$_2$Eq.)	Reductions (MMTCO$_2$Eq.)	
		Incr.	Cum.
001	$(133.56)	0.07	0.07
002	$(37.64)	0.30	0.37
003	$(33.51)	0.34	0.71
004	$(6.58)	1.79	2.50
005	$(3.78)	0.37	2.86
006	$4.94	0.44	3.30
007	$13.97	1.90	5.20
008	$25.33	1.00	6.20

Y-Axis X-Axis



**All tons are METRIC*

MMTCO$_2$Eq. = Million Metric Tons Carbon Dioxide Equivalent

Data Sources

- *Petroleum Systems*
  - CARB (2005). 2005 Almanac Projection Data. California Air Resources Board
  - EC 2001. *Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change* (European Commission)
- *Natural Gas Systems*
  - CARB (2005). 2005 Almanac Projection Data. California Air Resources Board
  - EPA (2003). *International Analysis of Methane and Nitrous Oxide Abatement Opportunities: Report to Energy Modeling Forum, Working Group 21.* Prepared by ICF Consulting for the US Environmental Protection Agency.
  - CEC (2003b). *Natural Gas Market Assessment.* California Energy Commission, August 2003

Data Sources (cont'd)

- ***Landfills***
  - EPA (2003). *International Analysis of Methane and Nitrous Oxide Abatement Opportunities: Report to Energy Modeling Forum, Working Group 21.* Prepared by ICF Consulting for the US Environmental Protection Agency.
  - CARB (2005). 2005 Almanac Projection Data. California Air Resources BoardEPA 2004.
  - EPA (2004b). Landfill Methane Outreach Program (LMOP) LFGTE Database of National Projects.
  - EPA (2004g). LFGcost (Landfill Gas Energy Cost Model). US Environmental Protection Agency, October 2004.
  - BFRS (2005). California Biomass Facilities Reporting System. University of California – Davis.
  - CEC (2004). *An Assessment of Biomass Resources in California,* California Energy Commission, February 2004.

Data Sources (cont'd)

- ***Manure***
  - EPA (2004c). Emissions Inventory Improvement Program document series, Volume 8, draft version.
  - EPA (2004d). *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2002.* US Environmental Protection Agency
  - EPA (2004f). *International Methane and Nitrous Oxide Emissions and Mitigation Data, Appendix B: Technology Characteristics.* US Environmental Protection Agency.
  - EPA (2003b). "Current Status of Farm-Scale Digesters," *AgSTAR Digest.* US Environmental Protection Agency, Winter 2003.
  - EPA (1997). AgSTAR Handbook: A Manual for Developing Biogas Systems at Commercial Farms in the United States, US Environmental Protection Agency. EPA-430-B-97-015, July 1997.

Data Sources (cont'd)

- ***Manure*** *(cont'd)*
  - CDFA (2004). *California Agricultural Statistics: 2003,* California Department of Food and Agriculture, Agricultural Statistics Service, October 2004.
  - USDA (2004). *Agricultural Baseline Projections to 2013,* US Department of Agriculture, Economic Resource Service, February 2004.
- ***Electric Power Systems***
  - CEC (2004b). *California Transmission Line Ownership,* California Energy Commission, December 2004.
  - CEC (2002). *2002-2012 Electricity Report,* California Energy Commission, February 2002.
  - EC 2001. -*Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change* (European Commission)

Data Sources (cont'd)

- ***Semiconductors***
  - EPA (2004d). *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2002.* US Environmental Protection Agency.
  - EPA (2001). *U.S. High GWP Gas Emissions 1990–2010: Inventories, Projections, and Opportunities for Reductions.* US Environmental Protection Agency.
  - Bartos, Scott C., Daniel Lieberman, and C. Shepherd Burton (2004). Estimating The Impact of Migration to Asian Foundry Production on Attaining the World Semiconductor Council's 2010 PFC Reduction Goal. Presented at 11th Annual International Semiconductor Environment, Safety and Health (ISESH) Conference, Makuhari, Japan, July 2004.
  - Census Bureau (2005). *Semiconductor and Related Device Manufacturing: 2002*.
  - IEA (2003). *Building the Cost Curves for the Industrial Sources of Non-CO2 Greenhouse Gases*, Report Number PH4/25, IEA Greenhouse Gas R&D Programme, October 2003

Data Sources (cont'd)

- ***Refrigeration/AC***
  - BEA (2003) Gross State Product by Industry for 2001: U.S. Economic Slowdown was Widespread. Available online at <http://www.bea.gov/bea/newsrel/gspnewsrelease.htm#4>, Table 4. Bureau of Economic Analysis, May 22, 2003.
  - EPA (2004e). *Costs to Abate International Ozone-Depleting Substance Substitute Emissions.* US Environmental Protection Agency.
  - EIA (2005) Early Release of the Annual Energy Outlook 2005. Energy Information Administration, U.S. Department of Energy, Washington, DC, DOE/EIA-0383(2005).January.
  - EIA (2004). Annual Energy Outlook 2004. Energy Information Administration, U.S. Department of Energy, Washington, DC, DOE/EIA-0383(2004).January.
  - CEC (2003). *California Energy Demand 2003-2013 Forecast.* 100-03-002. August 2003.

Data Sources (cont'd)

- ***Refrigeration/AC (cont'd)***
  - CARB (2004). *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, CARB, August 6, 2004.
  - SAE (2003a). *Alternative Refrigerants Assessment Workshop*. Presented at the 2003 Conference on Mobile Air Conditioning Technologies in Phoenix, AZ. Society of Automotive Engineers. July 14, 2003.
  - DuPont Customer Service (2004). List Prices of Refrigerants (based on single 25-pound cylinders). June 9, 2004.
  - IEA (2003). *Building the Cost Curves for the Industrial Sources of Non-CO_2 Greenhouse Gases*, Report Number PH4/25, IEA Greenhouse Gas R&D Programme, October 2003.
  - Rugh, John and Valerie Hovland (2003). National and World Fuel Savings and CO_2 Emission Reductions by Increasing Vehicle Air Conditioning COP. Automotive Alternate Refrigerant Systems Symposium in Phoenix, AZ. SAE. July 17, 2003

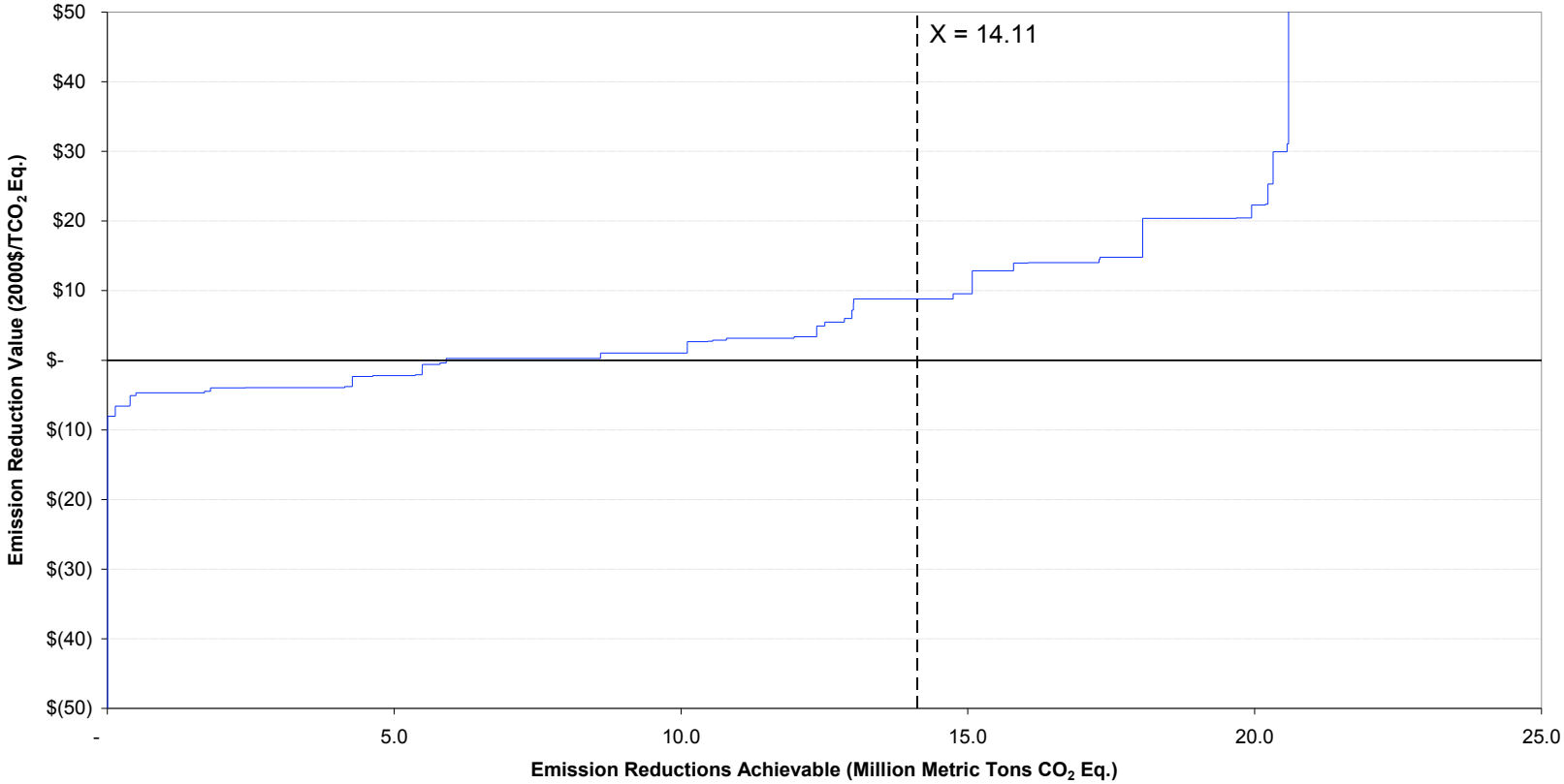
Results

- Options analyzed have the potential to reduce emissions by 20.7 $MMTCO_2$ Eq. in 2010 and 31.6 $MMTCO_2$ Eq. in 2020 – representing 51% and 55%, respectively, of baseline emissions for these sources
- Of these reductions, several options were estimated to yield a net savings (i.e., the total break-even cost was less than \$0/$MTCO_2$ Eq.)
  - 4%DR/0%TR: 2010 reductions of 5.9 $MMTCO_2$ Eq.; 2020 reductions of 8.7 $MMTCO_2$ Eq.
  - 20%DR/40%TR: 2010 reductions of 1.7 $MMTCO_2$ Eq.; 2020 reductions of 2.1 $MMTCO_2$ Eq.
- Landfill and manure management emissions represent the greatest reduction potential at the lowest costs

MACC Results

2010 Results, 4% DR; 0% TR

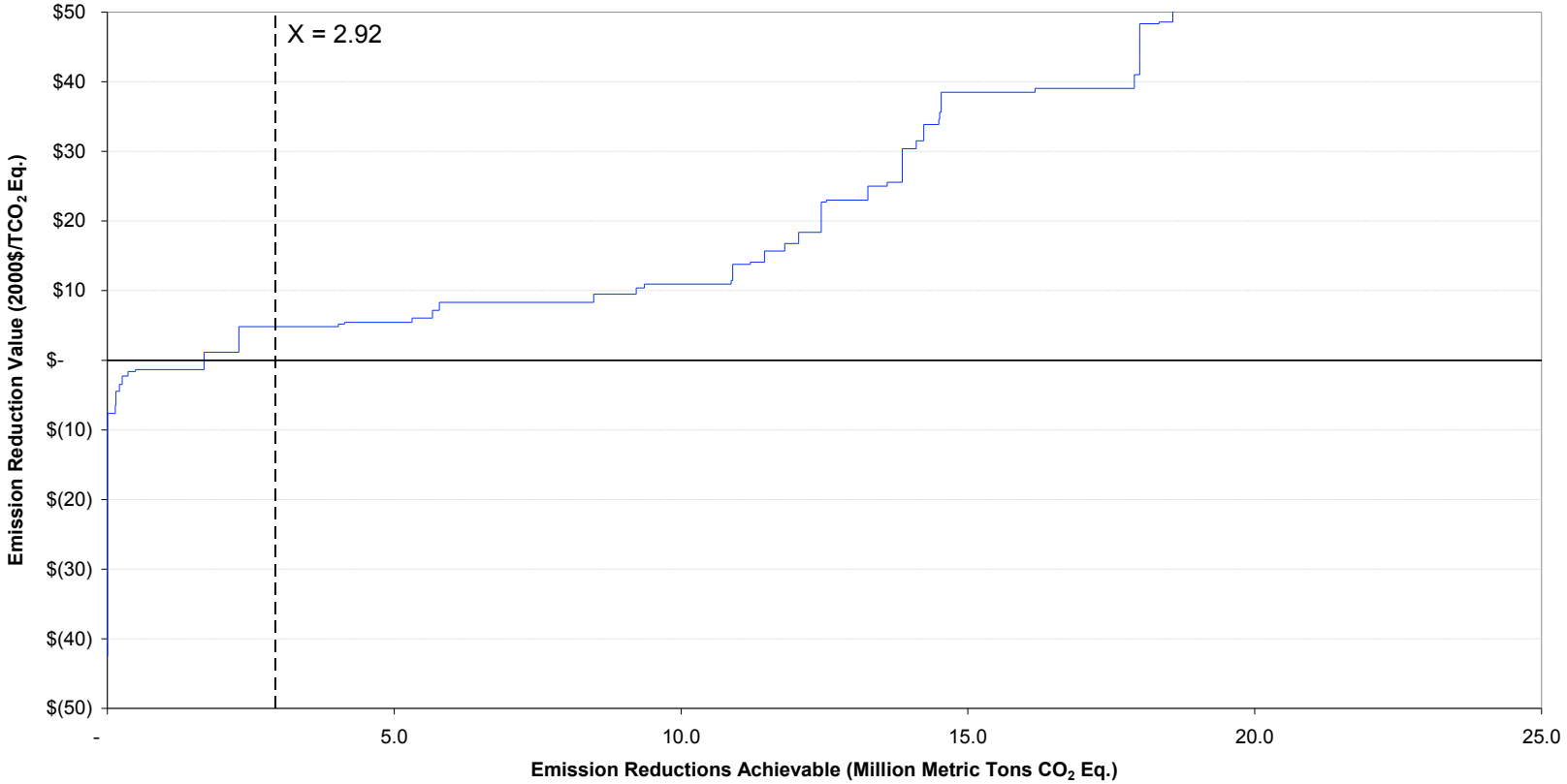
36 Mitigation options could be implemented to reduce emissions by 13 $MMTCO_2$ Eq. for zero net cost



MACC Results

2010 Results, 20% DR; 40% TR

12 Mitigation options could be implemented to reduce emissions by more than 2 $MMTCO_2$ Eq. for zero net cost

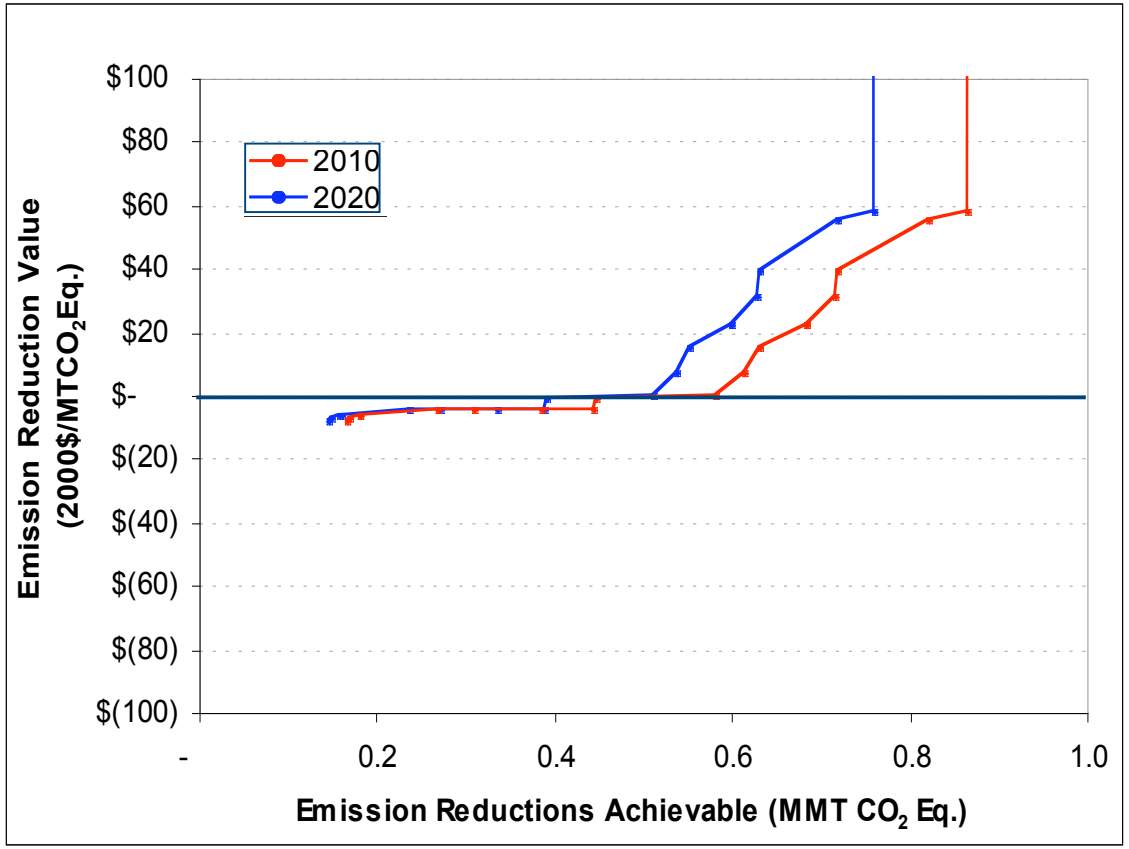


Source Results: Natural Gas Systems

Number of Mitigation Options: 22

Potential Emission Reductions for 2010 and 2020 $MMTCO_2Eq.$

(4% DR, 0% TR)

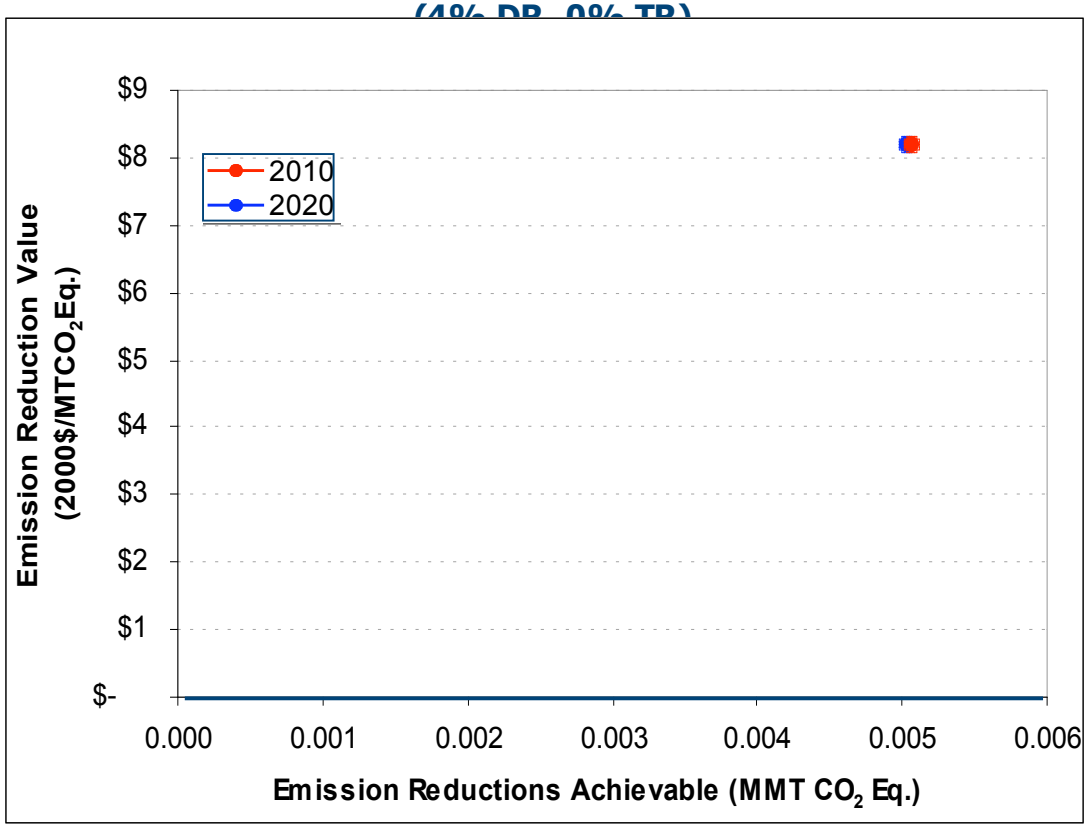


In 2020, 0.511 $MMTCO_2$ Eq. could be reduced at a break-even cost ≤ $0.

Source Results: Petroleum Systems

Number of Mitigation Options: 1

Potential Emission Reductions for 2010 and 2020
$MMTCO_2Eq.$

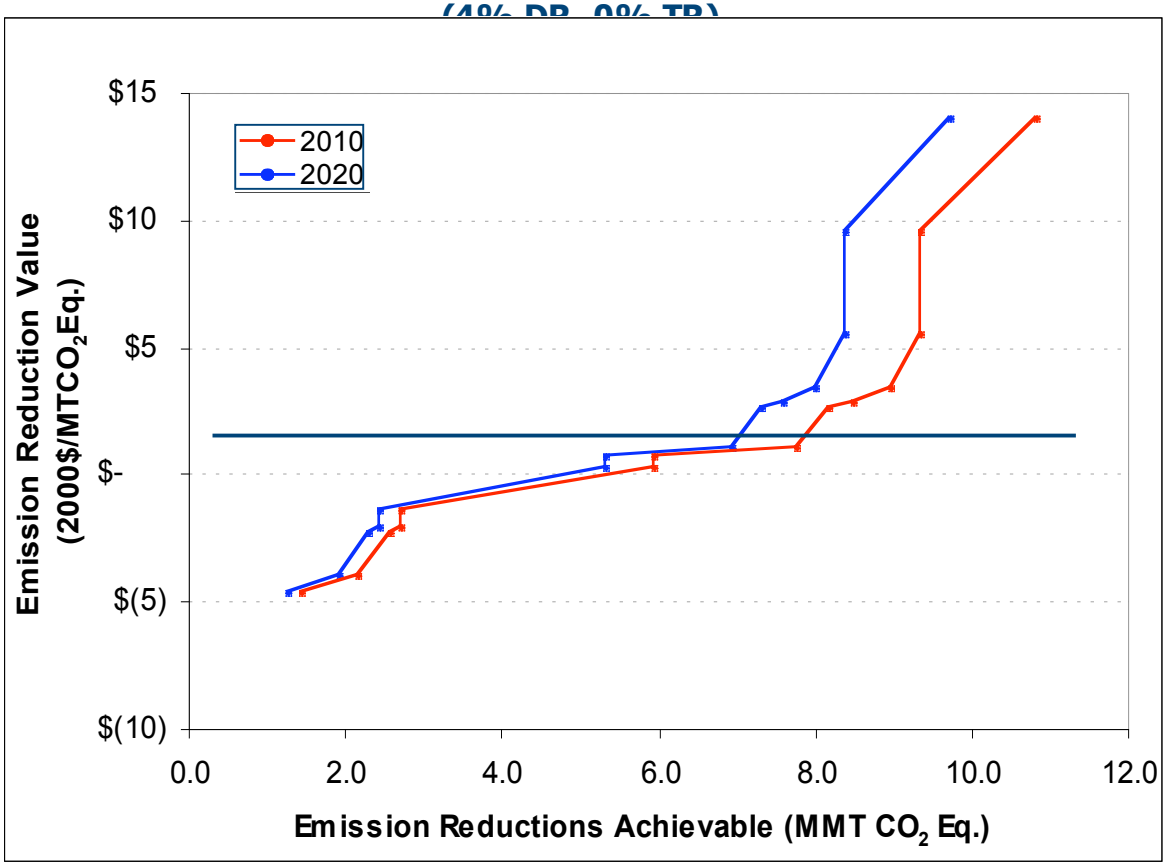


All reductions occur at a break-even cost > $0.

Source Results: Landfills

Number of Mitigation Options: 14

Potential Emission Reductions for 2010 and 2020
$MMTCO_2Eq.$



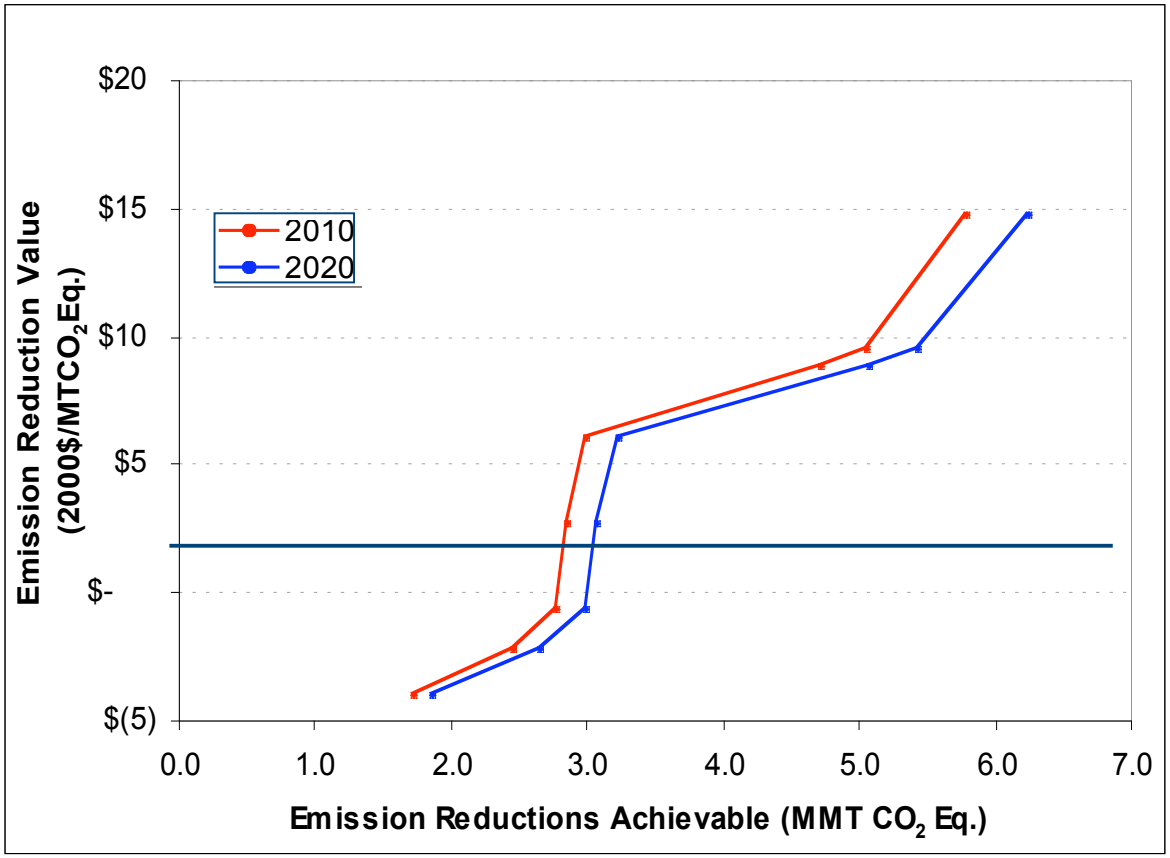
In 2020, 2.44 $MMTCO_2$ Eq. could be reduced at a break-even cost ≤ $0.

Source Results: Manure Management

Number of Mitigation Options: 8

Potential Emission Reductions for 2010 and 2020 $MMTCO_2Eq.$

(4% DR, 0% TR)



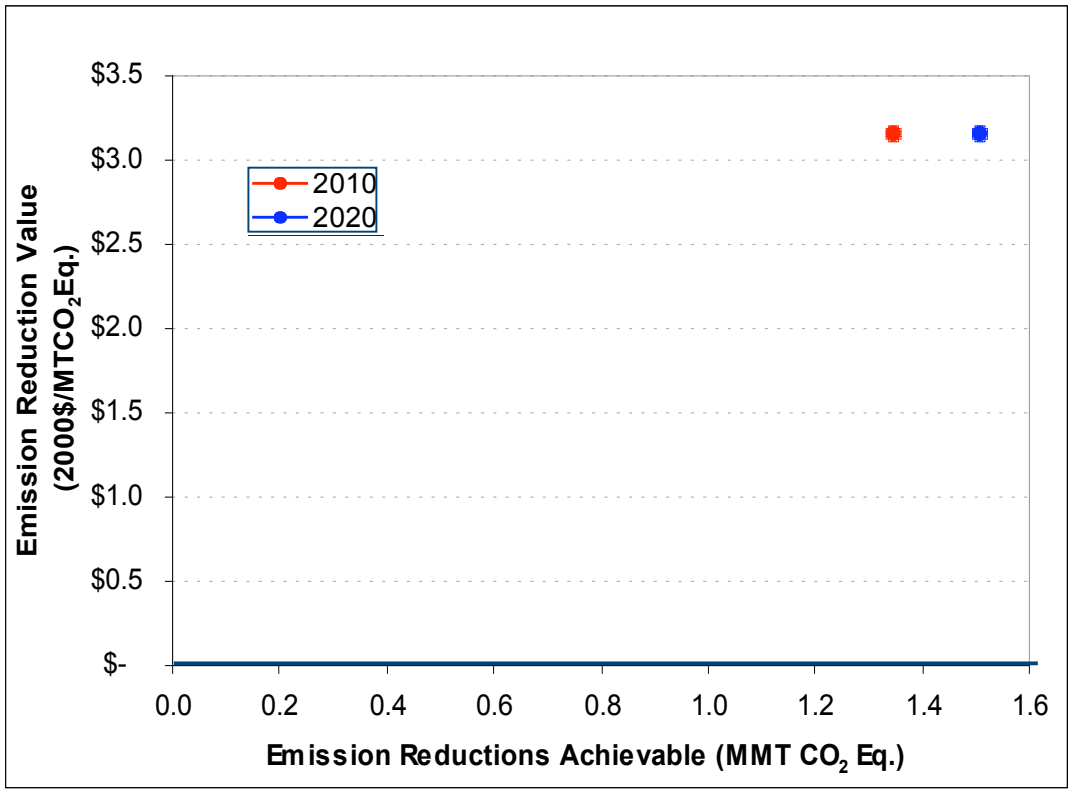
In 2020, 2.99 $MMTCO_2$ Eq. could be reduced at a break-even cost ≤ $0.

Source Results: Electric Power Systems

Number of Mitigation Options: 1

Potential Emission Reductions for 2010 and 2020 MMTCO$_2$Eq.

(4% DR, 0% TR)



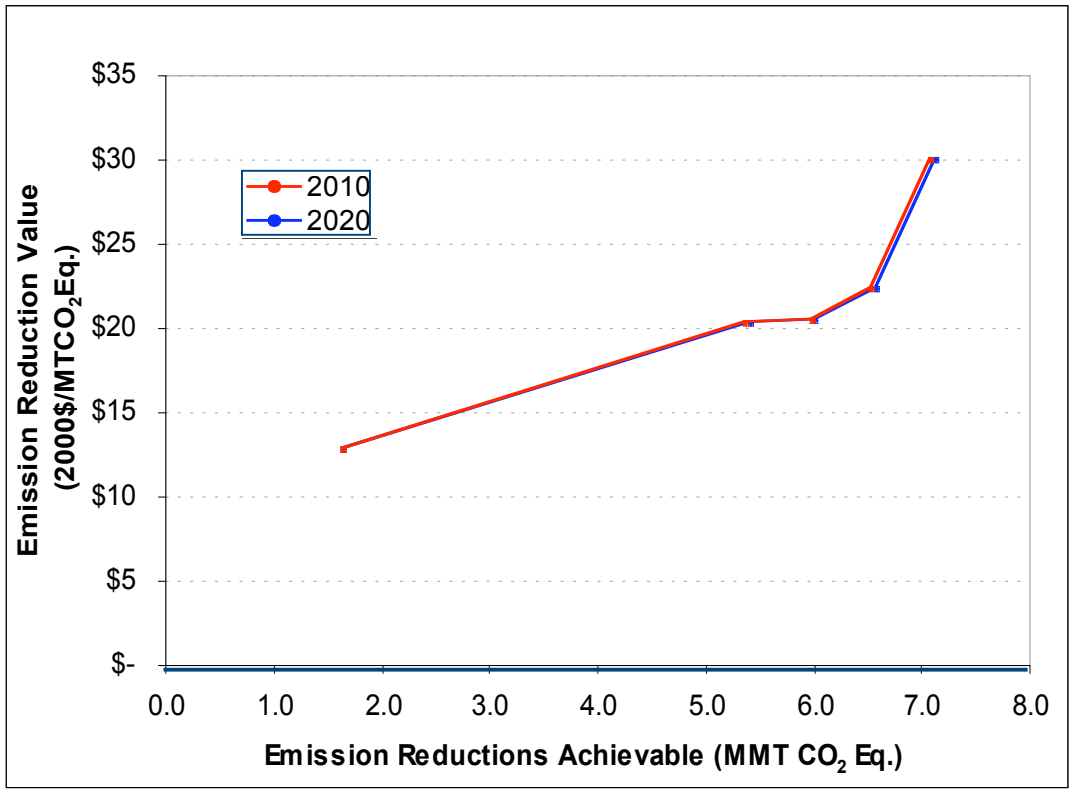
All reductions occur at a break-even cost > $0.

Source Results: Semiconductor Manufacture

Number of Mitigation Options: 5

Potential Emission Reductions for 2010 and 2020 MMTCO$_2$Eq.

(4% DR, 0% TR)



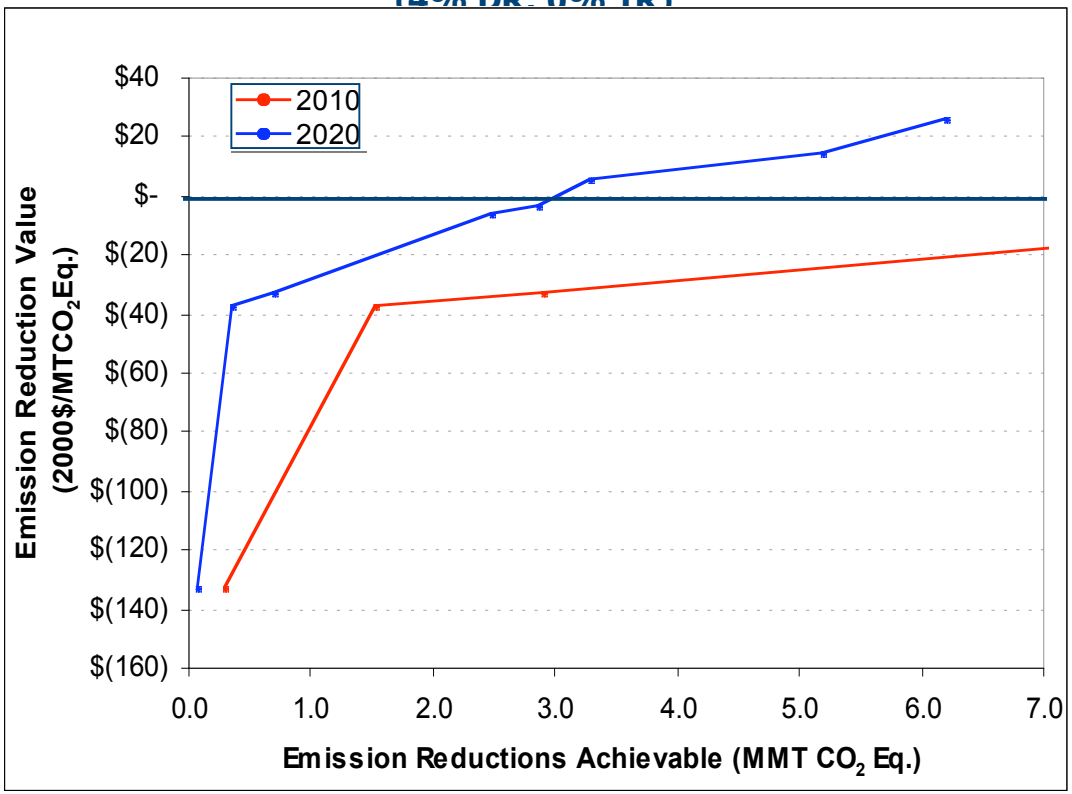
All reductions occur at a break-even cost > $0.

Source Results: Refrigeration/Air-Conditioning

Number of Mitigation Options: 8

Potential Emission Reductions for 2010 and 2020
$MMTCO_2Eq.$

(4% DR, 0% TR)



In 2020, 2.86 $MMTCO_2$ Eq. could be reduced at a break-even cost ≤ $0.

Next Steps

- Revisit baseline definitions to reflect impacts of regulatory actions and voluntary post-2000 (e.g., SMI goals, Pavley Bill, Global Warming Initiative)
- Revisit mitigation analysis to reflect revised baseline definition
- Revise/expand mitigation measures for dairy farms, refrigeration/AC (e.g., use of CO_2 as a refrigerant)
- Work with CIWMB to analyze additional measures to reduce methane emissions from landfills
- Revise semiconductor analysis to reflect forthcoming industry data